Study on the Transient Dynamic Characteristics of TLP under Impact Load

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ABSTRACT

Caused by the effect of transient impact load, the large-amplitude motions of platform main body may lead to mooring system’s fracture and endanger platform’s security. In this paper, numerical analysis method was employed to study the mooring characteristics and coupling dynamic response between tension leg platform main body and mooring system under different impact loads. The effect of three typical impact loads: sine pulse, triangular pulse and rectangular pulse were considered and the differential equation of motion was solved by self-compiling program. The effect of nonlinear damping, pulse shape, collision position, angle of attack, and the combined action of impact load and wave load on transient dynamic characteristics of platform were considered too. It was found that: under the three typical pulse loads, the computation results of surge and pitch response amplitude with nonlinear damping considered were both less than the results that nonlinear damping was ignored. The amplitude of platform motion responses was associated with the peak value of pulse. With the same pulse impulse, time histories of platform under the three pulse forms are basically in agreement with each other. Dynamical response of platform was affected by collision position and the angle of attacks. Affected by the combined action of impact load and stochastic wave load, large motion response of platform was mainly caused by impact load.

KEY WORDS: Tension leg platform (TLP); impact load; dynamic response; mooring characteristics.

INTRODUCTION

The tension leg platform (TLP), which is vertically moored, is a type of semi-compliant and semi-fixed platform. The sea environment induces a tremendous load on the platform, such as wave load, wind load, current load, and tide. In addition, TLP is also affected by some transient loads, such as falling objects, ships, icebergs and giant sea creatures’ collision load. A large number of studies on the motion responses and mooring characteristics of TLP under the combination of wind, wave and current have been carried out by some scholars (Gu et al., 2012a,b, 2013; Zou et al., 2011; Zeng et al., 2009; Chandrasekaran et al., 2007; Magee et al., 2011), but fewer studies on the transient dynamic characteristics of the platform under impact loading are conducted. The time-domain analysis method is mainly used in these studies.

Khan et al. (2006) studied the TLP dynamic characteristics, strength and reliability of tendon under the combined effects of random wave and impact load based on Von-Mises failure theory. The various random variables that affect the reliability of tendon such as the angle of attack, the platform immersion depth and the yield stress were analyzed by using sensitivity analysis method. Chandrasekaran et al. (2007) studied that in regular waves, on water depth of 1200 m and 527.8 m respectively, the dynamic response of triangular TLP pontoon under the 45° impact load. In the study, Stokes fifth-order wave theory was employed in wave theory, and Modified Morrison Formula was used to calculate hydrodynamic and concluded that: a greater dynamic response of TLP occurred when the impact was loaded on the pontoon than that on buoyant box. Syngellakis and Balaji (1989) used numerical simulation method for solving coupled nonlinear functions of motion for TLP, carried out research on the transient dynamic characteristics of elastic collision between ships and offshore platforms. Chen and Tan (2005) took use of forced vibration theory to determine the jacket platform’s vibration mode and natural frequency, followed by the research analysis on the dynamic response of jacket platform’s different nodes when it withstand the ice of 600cm/s, 45cm thickness. The results showed that: sea ice has “dynamic magnification” effect on jacket platform, the dynamic response trend of displacement and velocity along the x axis is to firstly increase and then decrease, and finally tends to equilibrium. Zhang and Zhang (2005) used Matlock model and Mattanen model to make a comparison of dynamic response of jack-up platform under different operating depth, ice thickness and ice velocity. It was found that: different operating depth has a certain influence on the ice-induced vibration; Mattanen model is only applicable to the self-excited vibration of platform; platform damping has a large impact on Mattanen model calculations, but has little effect on the calculation of Matlock model; the response cycle solved by Mattanen model equal platform’s natural period.